Increasing Forest Carbon Storage in Maine
by Mitch Lansky
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"How many legs does a dog have if I call his tail a leg? Four. Saying that a tail is a leg does not make it so."
Attributed to Abraham Lincoln

Summary:
This discussion paper argues that forest programs to increase carbon sequestration should have a goal to increase the average volume per acre of trees (AVPA), which is easily measured. In other words, landowners should be increasing carbon storage by growing more and bigger trees.

An important strategy for increasing AVPA is to have the rate of cutting be less than growth. Currently there are no regulations in Maine that require this basic silvicultural goal. Some landowners certified as "sustainable" have cut more than growth and drawn down their AVPA.

Landowners can use "passive management" (no cutting) to increase AVPA or "active management"--which would involve growing higher volumes of bigger trees and leaving more residuals after cutting.

Some companies are paying landowners in Maine and other states for "carbon offsets" to compensate for their emissions. It is not clear if these programs will lead to actual increases of stored carbon in the forest landscape, or if this is just a benefit on paper.

There are also claims that wood can be a substitute for fossil fuels for generating power, but there is strong evidence that the carbon emissions per unit of energy are greater with biomass than fossil fuels.

And there are also claims that there is a carbon benefit for substituting wood products for concrete and steel in buildings. But the actual benefits, if there are any, are smaller than what is claimed. A minority of what gets cut goes into lumber. Most wood markets in Maine, especially pulp and biomass, convert trees to carbon dioxide and methane in the relatively short term. Adding new markets, could lead to overcutting, not more carbon storage.

While the goals to reduce carbon emissions and increase carbon sequestration are laudable, it is not clear that the initiatives will meet their goals. These initiatives would have a better chance to actually achieve their goal if:

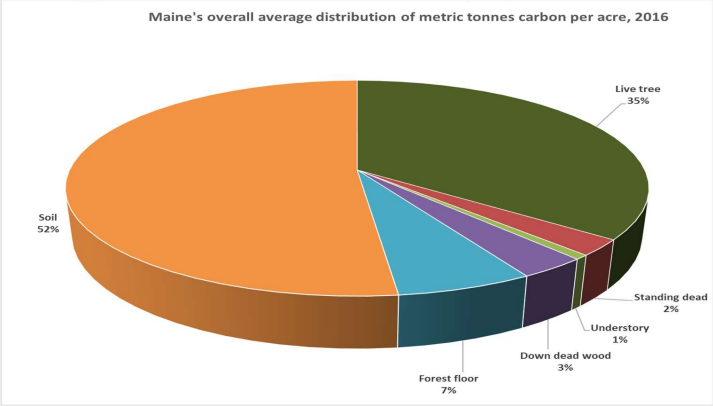
- The goals are explicit and the results expected of landowners across the landscape are measurable, and based on forest science.
- The increase in carbon storage across the forest landscape from the initiative is significant and cost effective compared to other initiatives designed to reduce carbon accumulation in the atmosphere.
- The initiative and the money expended must produce a change in forest practices that results in a measurable increase in carbon storage in forests at the state level.
- The results must be verifiably additional. T he initiative cannot simply pay landowners to do what they would have done anyway without a subsidy.

- Leakage should be avoided. The initiative should not lead to less cutting on some acres balanced out by more cutting on other acres so that there is little or no net benefit over the bigger region.
- The goal is to start reducing atmospheric carbon *now*—not decades into the future.
- Increases in forest carbon should start immediately and continue for as long as atmospheric carbon levels are an issue.
- Storing carbon for a few decades and then allowing heavier cutting, after the contract has ended, is not a viable strategy for mitigating climate change.
- The initiative is scalable for area and time. It can lead to carbon increases on enough acres (in conjunction with other initiatives) to make the needed difference.
- Funding must ensure independent and verifiable monitoring.
- There are positive impacts on biodiversity, recreation, and environmental quality. An increase in carbon storage should not compromise other important forest values.

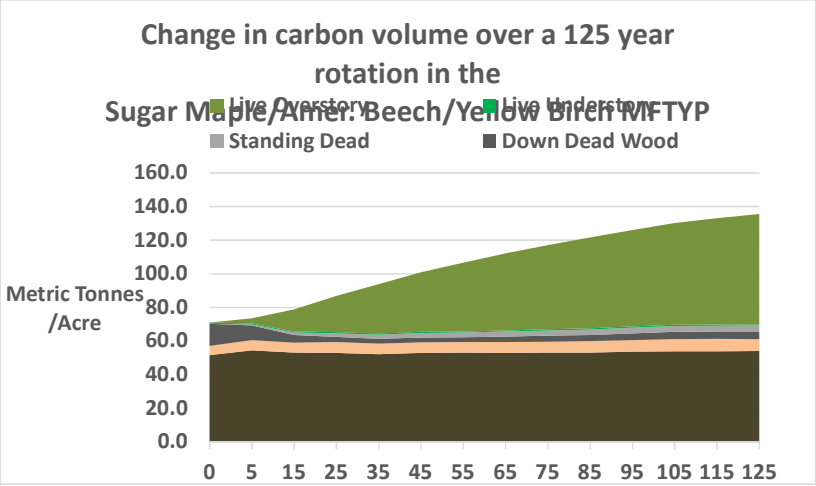
How do forests fit into goals for reducing atmospheric carbon?
If we are going to make an impact on greenhouse gasses that are contributing to climate change, then we need a double bottom line—we need to reduce greenhouse gas (GHG) carbon emissions and increase carbon capture and storage. Greenhouse gasses can persist in the atmosphere for decades, or even more than a century. Reducing emissions can *slow the increase* in GHGs, but carbon capture and storage can *reduce* GHG levels in the atmosphere.

There is a growing a recognition that Maine's extensive forests, that cover close to 9/10ths of the state's land area, represent a natural, and potentially cost effective way to capture and store carbon. Forest policy changes can lead to even more sequestration than there is now.

How can we measure progress toward the goal?
Forest carbon is stored in many "pools"--live trees, dead trees, forest floor, dead down trees, forest soil… The pool with the greatest capacity to significantly increase within a few decades is live trees. The graph below is the average for all forest types in Maine. Live trees (which include roots) stored only 35% of carbon in Maine's forest in 2016. Half the carbon was stored in the soil. But as a forest grows bigger and older, live trees can store the majority of carbon in the forest.



(See graph below of total forest carbon of northern hardwoods.[1]).



Kiln-dried wood is 50% carbon, so the higher the volume of wood stored in a forest, the more carbon there is in the forest. The more carbon there is in forests, the less carbon is in the atmosphere. A key goal for increasing forest carbon storage, therefore, is to increase the average volume per acre (AVPA) of forest trees across the landscape.

Measuring total carbon in a forest, accounting for all the pools, can be very complex and expensive. It can also require estimating the unknown carbon in the soil. Measuring above-ground live tree volume, however, is something foresters do routinely.

Increasing AVPA leads to more above-ground live-tree *storage,* but what about annual carbon *capture*?

Calculating annual movement (fluxes) of carbon from and between various "reservoirs," including forest pools and the atmosphere, is more complex and expensive than measuring AVPA. A certain percentage of carbon captured by trees is shared with fungi attached to tree roots. I've seen estimates of this pass-through carbon from the Pacific Northwest, but not for the northeast. Some of the carbon gets taken in by soil microorganisms. These figures are not easily estimated because they depend on so many variables of stand type, history, and location.

Both trees and soil organisms breathe in oxygen and breathe out carbon dioxide. When trees are cut, a certain percentage of the fiber goes to products, such as pulp and biomass, that release carbon dioxide within a relatively short time. Heavy cutting can not only remove trees with stored carbon, but also can lead to increased breakdown of soil organic matter, leading to more carbon dioxide and methane emissions.

1 From Maine Forest Carbon Estimator graphs. See http://www.meepi.org/lif/

Green-tree photosynthetic activity (an important part of "capture") does not account for dead wood. If dead wood accumulates over the long-term (multi-decades) this will show up as more carbon storage, but not more carbon capture. If the dead wood is harvested and burned, however, it will release carbon dioxide into the atmosphere.

There are and will be attempts to quantify such complexities, but, because of so many unknowns, so many variables, so many assumptions, differing scientists will come up with differing results. This variability in dealing with basic facts is not a good basis for establishing public policy.

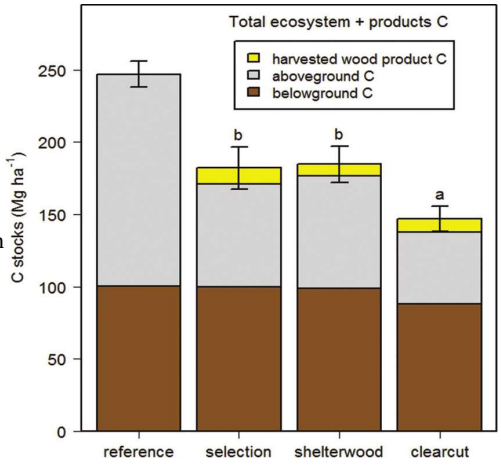
What management strategies can lead to an increase in average volume per acre?

Passive Management.

The quickest way to increase forest volume is through "passive management," or "proforestation"[2]--to reserve from cutting an existing forest and let it grow.[3] This strategy works especially well as policy when the "reserved" land is desirable for increasing late-successional forests on the landscape, as a "control" to forestry experiments, or as part of a designated wildlands.

Late-successional forests were once the context of the pre-settlement forest. This was the forest successional stage that lasted the longest. The habitats of large trees, dead standing trees, dead downed trees, and fungal diversity were important for biodiversity and forest health. Now late-successional stands are rare, isolated fragments.

The carbon benefits of letting forests grow old can be impressive. A recent study of 60 years of management at the Penobscot Experimental Forest, in Bradley, Maine, found that the uncut "control" had 52% more *total* carbon per acre than managed forests.[4]



A review of management strategies to increase carbon sequestration concluded that, "even with consideration of C sequestered in harvested wood products, unmanaged northern hardwood forests will sequester 39 to 118% more C than any of the active management options evaluated. This finding suggests that reserve-based approaches will have significant C storage value."[5]

Currently, less than 4% of the forest in Maine is officially reserved from cutting, so there is ample room for improvement.

2 https://www.frontiersin.org/articles/10.3389/ffgc.2019.00027/full
3 https://e360.yale.edu/features/why-keeping-mature-forests-intact-is-key-to-the-climate-fight
4 https://nsrcforest.org/sites/default/files/uploads/weiskittel11full.pdf
5 https://www.uvm.edu/giee/pubpdfs/Nunery_2010_Forest_Ecology_and_Management.pdf

(See appendix 1 to see calculations of how much increased carbon would be stored over six decades if 10% of current managed forest is set aside as reserves, assuming the rest of the forest keeps its current AVPA)

Active management.
It is also possible to increase average carbon per acre over a period of many decades across the landscape through active management. What makes management for higher AVPA different from Business As Usual is that the forests are allowed to grow more volume with bigger timber, and, after cutting, retain higher volumes of residual trees.

Commented [DRF1]: I would make that caveat as most people ignore it. Cutting never increases the AVPA, but a combination of lengthen rotation and less intense harvesting

What matters most is not just what happens on isolated acres, but *what the average volume is in the whole forested landscape, at all stages of growth*. For these strategies to be sustainable, the land manager would also have to assure that *cut is less than growth* over a rolling multi-year period. This is also a basic requirement of "sustainable" forestry.

In the 2008 Forest Inventory Analysis, the USFS states that "Net tree growth-to-removal ratios give an indication of resource sustainability by comparing estimates of harvest and other removals to net growth. […] if the ratio is less than 1.0, then the resource is decreasing."

Doesn't intensive management increase growth and lead to a sustained yield?
Some advocates of "intensive management" (clearcuts, site preparation, planting, herbicide spraying, pre-commercial thinning…), might argue that they are benefiting the climate by growing trees faster. They claim that their management is also "sustainable," even though they are cutting more than growth. Their method of accounting for cut and growth is called the "allowable cut effect" (or ACE).

Although in the short-term, these landowners are cutting more than growth, according to their computer programs, growth in the future will be so great as to compensate for lower growth now. Unfortunately, the atmosphere does not have the same computer program, and to help moderate climate change, we need to reduce atmospheric carbon *now*, not many decades into the future. In the mean time, short cutting rotations lead to a landscape that is younger, and supports a lower AVPA than practices with longer rotations and/or more residuals after cutting.

"Heavily harvested stands inevitably have less structural complexity, less dead and rotting wood, fewer hollow trees, thinner and less organic soils, and more surface runoff than lightly harvested ones," notes ecologist Jerry Jenkins, who has studied biodiversity issues in northeastern northern forests. "If the amount of biomass removed is a significant fraction of total growth, then no matter how good the owner's intentions are or how skilled the foresters and operators, there is no way that a harvested stand will have the same structure and ecology as an old-growth one."[6]

Nunery et al after reviewing studies on carbon enhancement management strategies concluded that: "Of the harvest treatments, those favoring high levels of structural retention and decreased harvesting frequency stored the greatest amounts of carbon."[7]

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6 CONSERVATION EASEMENTS AND BIODIVERSITY IN THE NORTHERN FOREST
Jerry Jenkins, 2008
The Open Space Institute and the Wildlife Conservation Society

7 http://www.uvm.edu/giee/pubpdfs/Nunery_2010_Forest_Ecology_and_Management.pdf

The *way* forests are managed is just as important as cut being less than growth. One can have the same average growth and the same average cut over time, yet have a very different impact on carbon storage, depending on whether one does clearcutting on short rotations, or partial cutting to a fairly high residual.

A hypothetical example illustrates the difference between an even-aged system and an uneven -aged system that both have the same average growth per acre per year. Let us assume that both systems have the full range of stands between the cut and the minimum residuals across the landscape. Let us also assume that the uneven-aged system is in a typical "Acadian Forest," with a majority of trees that are either shade tolerant or intermediate shade tolerant.

If the even-aged system cycles between a clearcut (leaving behind zero cords) and 30 cords per acre for a 60 year rotation, the average volume per acre in the landscape would be 15 cords and growth per acre per year would be ½ cord.

If the uneven-aged system cycles between 22.5 and 30 cords per acre, for a 15 year cutting cycle, then the average volume per acre in the managed landscape would be 26.25 cords per acre—*75% more than the 15 cords per acre in the even-aged system!*

Both systems are growing at ½ cords per acre per year, but the uneven-aged system *stores* more carbon, and has bigger, more valuable trees. Also, every 60 years the even-aged system is subjected to heavy cutting that could lead to soil carbon losses.

Short rotations completely eliminate later successional stages, and even longer rotations have a very small percentage of land in late-successional growth stages. So there are biodiversity issues as well as carbon issues to be considered when choosing cutting systems and cutting cycles.

Note, the goal is not to maximize the average growth per acre per year during a brief stage of growth on limited acreage. *If the forest grows faster, but it is also cut faster, forest tree volume does not increase, and thus forest carbon storage does not increase.*

(See appendix 2 for calculations on how much more carbon would be stored if forests in Maine were managed to the AVPA of Maine's public lands. The 600 thousand acres of public lands have 23 cords to the acre and are growing more than 20% more volume per acre per year than the current average for the whole state).

Aren't most commercial forest operations meeting sustainable state regulatory and private certification system guidelines?

Out of the 17.5 million acres of timberlands in Maine, 11 million are in the Tree Growth Tax Law (TGTL) program. In the 1972 enabling legislation for the TGTL, a stated goal for forests under the program is: "to encourage their operation on a sustained yield basis*,"* also, "to promote better forest management by appropriate tax measures."

The TGTL is a current-use tax that causes a shift in taxes from forest land owners to home owners and from property tax to income and sales taxes. The state spends millions of dollars each year reimbursing towns for a proportion of lost revenues due to the lower tax rate.

The TGTL, however, does not have a quid pro quo, or "strings" in exchange for the lowered tax rate. The TGTL does not require the landowner to cut less than growth or avoid high-grading, even though that might be an aspiration for the program. There *is* a requirement for a management plan signed by a registered professional forester, but there is no requirement for the management plan to actually achieve some minimal silvicultural goal.

The Society of American Foresters (SAF) has a Code of Ethics that states: "Foresters have a responsibility to manage land for both current and future generations. We pledge to practice and advocate management that will maintain the long-term capacity of the land to provide the variety of materials, uses, and values desired by landowners and society." Cutting more than growth and/or highgrading do not seem to contribute to a long-term management of ecosystems, nor do they indicate a concern for future generations.

Has the Tree Growth Tax Law, combined with the requirement for management plans signed by registered professional foresters, led to more average volume per acre in counties where the bulk of forestland is under this current use tax program?[8] County forestry statistics show the opposite:

Counties dominated by forestland under Tree Growth

County	**Cords/acre**
Washington	15
Aroostook	15.4
Somerset	15.5
Penobscot	17.5
Piscataquis	18.1

Counties with lower percentages of forestland under Tree Growth

County	**Cords/acre**
York	26
Cumberland	29
Androscoggin	30
Lincoln	30
Sagadahoc	30

While it would not be fair to say that the TGTL combined with a requirement for management plans *caused* less productive forestry, it is fair to say that this program *has not prevented it*.

An article in the *Journal of Forestry* by Charles Brockett and Luke Gebhard on "NIPF [Non-Industrial Private Forest] Tax Incentives: Do They Make a Difference?"[9] found no significant correlation between lower-tax rates and improved forestry or reduced development. The authors concluded that the tax program studied (in Tennessee), "has functioned as a windfall for participating landowners without providing commensurate return for the rest of the area's citizens."

8 Calculated from https://apps.fs.usda.gov/Evalidator/evalidator.jsp

9 *https://academic.oup.com/jof/article/97/4/16/4614026*

The article by Brockett and Gebhard did not reject current-use tax programs. Instead, the authors concluded that there should be *more* strings attached: "For example, participating owners could be required to have a *meaningful* management plan with effective oversight of *compliance*." (their emphases)

But of the 11 million acres under Tree Growth, 8 million acres are *certified* to be sustainable by Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), and American Tree Farm (ATF). Surely, on these certified lands, cut is less than growth?

One would think that sustainable forestry certification would represent the "oversight" mentioned in the *Journal of Forestry*. While these private certification programs were not designed to certify that landowners are increasing the storage of carbon in their forests (though at this point in time, carbon storage *should* be a certified outcome), one would assume that any definition of "sustainable forestry" would have as a requirement that over a rolling time period, cut is less than growth. But, there are times and places in Maine where this has not been true.

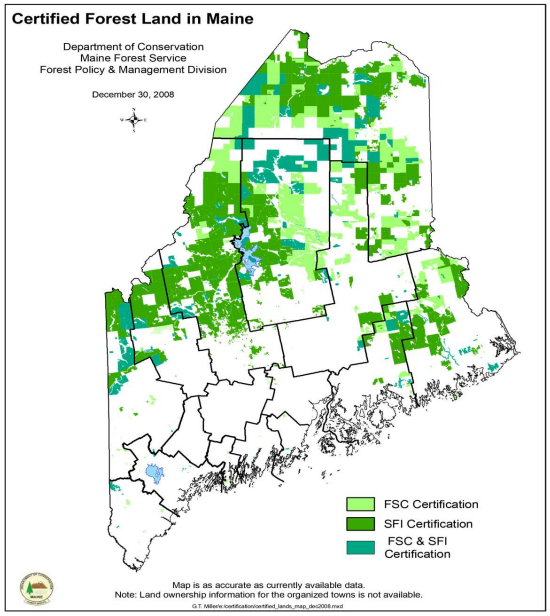
According to research by Robert Seymour and David Sherwood at the University of Maine, large, private certified forest acreage from 1999 to 2012 (23 years) was cut faster than the wood was growing back.[10] FSC, but not SFI ownerships, at the time of the study, were starting to come back into a better balance, but most of the increased growth was in balsam fir, rather than more valuable species such as red spruce and rock maple.

Seymour and Sherwood also found that "Big, valuable trees, which produce logs for the region's sawmills are being harvested much more intensely than they are growing."

The counties that have the highest percentage of certified acreage also have the highest percentage of land in seedlings and saplings (37% in the northern three counties), the most acres clearcut, the most herbicide spraying, and, as seen in the above list of counties, the lowest average volume per acre.

Data from the Maine Forest Inventory Analysis of 2008 confirms the trends found by Seymour and Sherman. The Northern Megaregion (Aroostook, Piscataquis, and Somerset Counties), has a high concentration of certified ownerships, including land certified under FSC standards.

10 http://nsrcforest.org/project/assessing-maine%E2%80%99s-certified-sustainable-timber-harvest



Here are some examples from the Northern megaregion, contrasted with southern Maine counties (York, Cumberland, Androscoggin, Lincoln, Knox, and Waldo Counties) that have a much smaller proportion of certified acreage:

- The growth to removal ratio (G:R) for all species in the Northern megaregion was 0.79. In the Southern Megaregion the growth to removal ratio was 2.33.
- The growth to removal ratio for softwoods in the Northern region was 0.92. In the Southern region it was 1.89.
- The growth to removal ratio for hardwoods in the Northern region was 0.63. In the Southern region it was 2.86.
- In the Northern region the G:R for red spruce was 0.54, and for the whole state it was 0.67.
- The Northern region G:R for sugar maple was 0.53, and for the whole state was 0.67.
- In the Northern region, spruce-fir volumes declined by 2.1% from 2003-2008. The decline was even greater for hardwoods—6.4%. The document (page 18) makes it clear that "both declines are attributed to ongoing harvest levels."

Certification has not caused those outcomes, but it also hasn't prevented them. These are also not outcomes that most of the public would think of when asked to describe certified "sustainable" forestry.[11]

Why concentrate on figures from the 2008 FIA? Isn't the forest now recovering volume?

11 To read *Recommendations to FSC-US to Make Forestry Certification More Credible*, written in 2001, go to http://www.meepi.org/lif/

After 2008, in response to a major recession and a series of paper mill closures, the total level of cut in Maine went down. The average annual cut of all timber products between 2008 and 2018 was 16% lower than the average annual cut of all timber products between 2000 and 2007.

Also, trees from the big clearcuts of the 1980s especially fir, red maple, and spruce, are now over 5 inches in diameter and are counted as part of the total growth. So, much of Maine now has growth greater than cut. This change had more to do with economics and markets than with deliberate policies to manage more sustainably or to sequester more carbon.

Is the problem with Maine's forests too much regulation? Isn't that why the Maine Forest Service created the Outcome Based Forestry program?
In a 1999 State of Forest report, the MFS wrote: "We have reached the limits of what a command and control regulatory framework has to offer." "Command and control regulation has many limitations and may result in unintended consequences, such as forest fragmentation and premature harvesting to recover equity in a forest investment."

At this point one must wonder how we have reached the limits to forest regulation when it should be obvious that there are no regulations that impact the basics of forestry, such as cut being less than growth or restrictions on highgrading. The "unintended consequences" are the result of a *lack* of regulatory oversight, not an *overabundance*.

The reward to participants in OBF is to be exempt from Maine's Forest Practices Act (FPA), a law that regulates the size and distribution of clearcuts. If a company participates in OBF, it can have bigger clearcuts and smaller separation zones than would be allowed under the FPA.

There is nothing in the FPA that compels landowners to cut heavily or highgrade. If there were no FPA, landowners who want to maximize short-term removals would be able to do even worse damage. For those landowners who want to do "sustainable" management, there is also nothing in the FPA that prevents them from doing stand improvement cuts that leave better quality residuals. Better forestry has always been an option with or without the FPA.

But, for a handful of landowners, restricting the size of clearcuts is so egregious that they need an alternative system that exempts them. There is an economy of scale for machinery and herbicide use that favors bigger clearcuts, but this is an economic, rather than biological, benefit.

As with certification, OBF does not have any listed outcomes that promote increased carbon storage over the landscape. OBF uses the results of certification as evidence that sustainable forestry is taking place. While the Maine Forest Service is calling the program "outcome based," there are no clear, measurable standards that would define when an outcome is reached. It is up to the judgement of the technical committe to determine if outcomes have been reached or not.

Unlike sustainable forestry certification, carbon offsets are designed specifically for increased carbon sequestration. Are these transactions leading to the promised results?
If the programs actually lead to an increase of the average volume per acre of forests, yes. But, some of the initiatives, based on what can get funded, are likely to fail at meeting stated goals.

A growing number of large corporations have publicly stated that they intend to be "carbon neutral" or "zero net carbon" by certain dates. They will do this not only by reducing their substantial emissions, but also by funding carbon "offsets," to make up for the emissions that they don't think they can profitably reduce.

Some of these offset programs are now operational in Maine. But do these programs actually make a measurable difference and are the expenses justified by the results? And does money for carbon offsets yield better benefits than it would if invested in alternative carbon reduction schemes?

The jury is still out because the programs are still new and being developed. Some very large carbon-emitting companies are spending big money on offsets, rather than doing the necessary work to reduce their carbon emissions.[12][13][14] Some critics have called such expenditures the equivalent of medieval "indulgences," where the wealthy can pay money to the local priest to make sure they can get into heaven without having to be "good."

Those with enough money to invest in forest carbon offsets can fly in jets, build mansions, or drive inefficient SUVs because they can "offset" the carbon emissions.

One study, from MIT, raised the possibility of perverse consequences of offsets, such as extending the viability of coal mines.[15] Another article mentioned timber companies in California cutting mature, diverse forests and replanting with a handful of quick-growing species.[16] Because there is no standard way to calculate the carbon, environmental, and other costs and benefits over time, there is ample room for fudging.

Other policies that would bring question to whether the program truly wants to solve a problem, rather just say that a problem is solved include the following:

- Land ownerships are paid to have the same AVPA as they had before the offset payments. So, the program payments will not lead to an increase in average volume per acre.
- Payments go to a minority of landowners. The majority, not being part of the program, can decrease their AVPA.
- The program has no clear desired stocking standard for AVPA. The agreed on stocking could be chosen by the landowner.
- The stocking standard for AVPA is based on being above the current regional average (which for some counties is quite low). This would require Lake Woebegone forestry, where every landowner has to be above average.
- The program is funding intensive forestry that would actually lead to a reduction of AVPA. For example, a program of the American Forest Foundation and The Nature Conservancy will fund "Enhancing Future Forests." This program, "promotes robust successful regeneration of new forests by having the landowner reduce competing vegetation following or preceding a regeneration harvest." Sounds like the program would fund spraying herbicides over a clearcut.

12 https://www.wired.com/story/do-carbon-offsets-really-work-it-depends-on-the-details/
13 https://www.weforum.org/agenda/2019/12/explainer-going-green-does-offsetting-carbon-emissions-count/
14 https://www.theguardian.com/travel/2019/aug/02/offsetting-carbon-emissions-how-to-travel-options
15 https://www.technologyreview.com/2019/08/26/133261/whoops-californias-carbon-offsets-program-could-extend-the-life-of-coal-mines/
16 https://sfpublicpress.org/news/2013-07/californias-market-for-hard-to-verify-carbon-offsets-could-let-industry-pollute-as-usual

- The funding agency does not have enough money to pay for offsets over enough land to ensure an increased AVPA for Maine and/or does not have the resources or stability to monitor participating ownerships for the coming decades.
- The program has, as a primary goal, that the current level of cut needs to be maintained. The primary goal should be for the volume of the forest to increase.

There are some statewide analyses that show annual rates of forest carbon capture and compare it to annual rates of greenhouse gas emissions. With this line of thought, storage is not as important, and one can ignore the carbon emissions that come from forest practices and short-lived forest products, such as biomass.

These studies have suggested that our forests are capturing perhaps 75% of CO2 emissions. And if emissions are reduced by 25% or the state buys offsets elsewhere, Maine can be "carbon neutral."[17] This can get confusing if California-based corporations paying for carbon offsets of Maine forests want to claim the sequestration belongs to them, and not Maine.

What about easements with stocking standards?
Some conservation easements call for landowners to have some form of sustainable forest certification. As noted, this does not always lead to higher stocking. But some go further and specify a minimum average stocking standard. A minimum average stocking level is a simple tool that has the potential to have significant impacts. One early example, the West Branch easement, however, has a minimum stocking level of 12 cords to the acre. This standard is way lower than the average volume per acre for even the worst-stocked counties. It is a hurdle that is subterranean.

In contrast, the Reed Forest Easement, held by the Forest Society on land currently owned by the Conservation Fund, has a minimum average stocking standard of 17.5 cords to the cord. This figure is close to the average volume per acre for the state at the time of the creation of the easement. It is not a biologically-based benchmark.

Even though, for carbon storage, the minimum stocking should be higher, the stocking standard in the Reed Forest is having an impact. Before the Conservation Fund bought (with the help of Apple Corporation) the Reed Forest, the land had been owned by The Forestland Group (certified by FSC), and before that Fraser Paper Company (certified by SFI). After decades of certified ownership, the stocking in the Reed Forest was so low, that the easement allows the landowner to take up to twenty years to reach the minimum stocking standard. The result is that the current landowner has to restrict harvesting rates until that minimum is reached.

Unfortunately, despite the "sustainable" forestry previous to the Conservation Fund, the town population has already been halved, local logging contractors went out of business, the local school was closed, the local store shut down, and most of the young people have left for better job opportunities.

Aren't there big carbon benefits from switching to "green" wood markets?
Some industry analysts and advocates are arguing for substituting wood biomass for fossil fuels for energy, and also lumber products for concrete, and steel. Advocates of these substitutions have gone so

17 https://crsf.umaine.edu/forest-climate-change-initiative/carbon-budget/

far as to say that these wood products prevent so much carbon emissions that using them is more important than increasing forest carbon storage.

Even though burning biomass emits more carbon dioxide than does coal per unit of electricity generated, it has been labeled "carbon neutral" and is now the number one "renewable" energy source in Europe.[18] Some biomass plants in Maine are less than 20% efficient at turning wood energy into electricity, less efficient than coal.

Biomass advocates posit that you don't need to count the carbon emissions from burning biomass because the CO2 emitted is taken up by other trees. This astounding argument implies that trees sequester carbon emitted by burning other trees but not carbon emitted by burning fossil fuels. Otherwise, why can't natural gas power plants in Maine argue that because Maine has so many trees, their power plant emissions are also canceled out—zero net carbon.

There is scepticism among scientists that cutting more trees to feed the biomass markets is a formula that leads to some certifiable environmental benefit. Increasing biomass burning not only leads to higher short-term emissions, it also leads to less carbon capture and storage, because there are fewer trees.[19]

There is more excitement, however, over cross laminated timbers (CLT) as a substitute for concrete and steel, both of which have heavy carbon footprints. Part of the excitement is that, unlike biomass, where the wood harvested is soon burned, the CLT carbon stays in the wood, which stays in a building as long as the building stands. This is true of all lumber, of course, but CLT, unlike most other forest products, can build taller buildings.

In Maine, 2018, 35% of what got cut was sawlogs, 40% was pulpwood, and 20% was biomass and firewood.[20] Most pulpwood and all biomass end up as CO2 emissions in the short term. Of sawlogs, a certain percent ends up as culls, slabs, edgings, planer shavings, and sawdust, most of which go to pulp or biomass markets. A small minority of what gets cut, therefore, ends up in long-standing buildings. And it takes energy to cut, yard, transport, process, and manufcature forest products.

According to a six decade study at the Penobscot Experimental Forest in Bradley, Maine, the carbon accumulated in a "reserve" forest, where there is no cutting, is greater than the carbon accumulated in managed forests, *even if one takes into consideration the carbon stored in lumber in buildings and landfills.*[21] Other studies have come to similar conclusions. For example, Nunery et al concluded that "Mean carbon sequestration was significantly greater for ''no management'' compared to any of the active management scenarios."[22] This study, in looking at active management included carbon stored in wood products.

18 See, for example https://e360.yale.edu/features/carbon-loophole-why-is-wood-burning-counted-as-green-energy
19 https://thehill.com/opinion/energy-environment/496021-burning-wood-is-not-a-solution-to-climate-change
20 file:///C:/Users/Mitch/Downloads/2018_WoodprocessorReport%20(2).pdf
21 Https://nsrcforest.org/sites/default/files/uploads/weiskittel11full.pdf
22 http://www.uvm.edu/giee/pubpdfs/Nunery_2010_Forest_Ecology_and_Management.pdf

Those who argue for product substitution as a key strategy for reducing carbon emissions assume at the start that the saw timber comes from sustainably-managed forests. As mentioned earlier, this assumption is questionable.

There are studies that dispute that wood has a smaller carbon footprint than steel or concrete.[23]

So, we have the possibility of an increased new market, added to existing markets, that could lead to increased cutting to meet mill demands. And there are no protections in Maine to prevent landowners from cutting more than growth to supply those new markets.

Summary and Conclusion

While it is recognized that forests in Maine are important for storing carbon, some of the solutions to address climate change that are now being used or discussed to be used do not set a clear goal of how much to increase carbon storage in Maine forests, and how much to reduce emissions from Maine forest industries.

The solutions also do not give a total cost for reaching the undeclared goal. There is talk about payments to landowners, but there are few discussions of measurable targets of what practices on the ground could qualify, or how intense or costly will be the monitoring to assure that the minimum targets are being reached.

There is mention in some of the proposals of paying landowners to maintain current levels of stocking for a given amount of time. But, how can this be a solution? If only some landowners apply for the programs, but the rest do not, and if markets are increased, then cut will go up, and volume down, on the acreages that are not sustaining current levels of stocking. This increase in cut might even be argued to be good because wood products store carbon. If this is the case, money will be spent to prevent more carbon from accumulating in the atmosphere but the result instead would be less carbon stored per acre of trees and more carbon emissions.

Having cut be less than growth as part of TGTL would be a good start in raising the average volume per acre for the state. Another approach that shows promise, because the goal is so clear, is managing to have more than a minimum average volume per acre, by timber type, over the forest ownership.

If landowners do not have adequate wood to cut so that they could leave the minimum stocking, they can still get credit for having a management plan showing how they will get to the desired volume per acre. As with the Reed Forest, they can either cut very little or cut not at all as their forest recovers. In either case, the forest will be growing and carbon will be accumulating.

Dealing with climate change is not a game. We are in a real world with real threats. There are catastrophic consequences predicted for the future if we continue in the same direction. And these consequences are not theoretical, they have already started: droughts, wildfires, super storms, floods,

23 https://archive.thinkprogress.org/which-emits-the-most-co2-in-home-construction-steel-concrete-or-timber-a6a8b2d3370f/
https://www.buildings.com/buzz/buildings-buzz/entryid/445/steel-the-more-sustainable-building-material
https://e360.yale.edu/features/as-mass-timber-takes-off-how-green-is-this-new-building-material
https://www.giatecscientific.com/education/defending-concrete-most-sustainable-construction-material/

dying coral reefs, dead zones in the ocean, melting permafrost, rising oceans, extinctions... the prediction is that they will increase in size, intensity, and frequency as the climate becomes more unstable.

Forests have limits. We cannot replace all the concrete and steel buildings with wood. There are too many tall buildings and too few acres of forest. It is certainly desirable to have markets for wood products that continue to store carbon for many decades, but if these markets are in addition to pulp and biomass rather than instead of them, and if there are no regulations to prevent overcutting, some landowners will overcut as long as they can make it profitable.

At some point society has to recognize that consumption on a limited planet can not grow geometrically forever into the future. Part of the strategy to protect forests has to be to reduce demand through better efficiency, recycling, substitution, and frugality. It is hard to believe that society is truly concerned with reducing carbon emissions if it does not invest in the strategies that have the lowest cost and the fastest returns, such as reducing the enormous waste of resources.

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Appendix 1

How much more carbon would we store if we used passive management (reserves) on 10% of land currently under management?

Assumptions: Maine has 17.5 million acres.
One tenth of this is 1.75 million acres.
Over 60 years, uncut reserves can have 50% more carbon per acre than managed acres.
There is (as of 2016) an average of 100 metric tons of carbon per acre in the managed forests in Maine.
50% more carbon would be a 50 metric ton per acre increase.
50 metric tons per acre times 1.75 million acres is a 87,500,000 metric ton increase in total carbon in Maine.
There are 2205 pounds per metric ton. A pound of carbon is worth 3.67 pounds of CO2. Cars that get 30 mpg emit 0.667 pounds of CO2 per miles.
The 87,500,000 metric ton increase in carbon storage is the equivalent of the carbon emitted by more than 88 million cars that get 30 mpg and drive 12,000 miles a year.

Appendix 2

How much more carbon would we store if we used active management using Public Lands standards (AVPA of 23 cords to the acre)?

Assumptions: Maine has 17.5 million acres.
The average volume per acre in Maine is 18 cords.
The average volume per acre on Maine Public Lands is 23 cords.
That 23 cords AVPA represents as 28% increase over current levels.
Above ground live tree volume currently contains around 30% of total carbon.
A 28% increase of 30% of total carbon represents an 8.4% increase in total carbon.
An 8.4% increase in 100 metric tons per acre would be an increase of 8.4 metric tons per acre.
Multiplying that figure by 17.5 million acres would yield an increase of 147 million metric tons of carbon in Maine.
This is the equivalent of the carbon emitted by 149 million cars that get 30 mpg and drive 12,000 miles a year.

In 2019, there were approximately 120 million cars on the road in the United States.

Appendix 3

What to expect if there is an attempt to make existing programs for sustainable forestry actually work?

In 1998, a bill, LD 1866, was introduced to the Maine legislature that would have put measurable standards into the Tree Growth Tax Law. While the goals in the original enabling legislation for the TGTL were precatory—more of a wish or aspiration than a mandate, LD 1866 tried to make the wishes come true. It established a process by which the Maine Forest Service would define terms and set standards. Management plans would have to show how the landowner would cut less than growth and improve stand stocking and quality. The bill also recommended a random annual audit to determine if landowners had such plans and, if so, if they followed the intent of the plans.

The press in Maine did not cover the bill or the hearing on the bill. The hearing room, however, was packed, mostly with industry representatives and lobbyists. Here are some of the major arguments against the bill (some of which might be used again if a similar bill is proposed):

- *There is already accountability. Management plans need to be approved by registered professional foresters.* Ah, would that this were the case.
- *The bill is too prescriptive. It won't allow good forestry.* Let me understand this. "Good forestry" means cutting more than growth, leaving understocked stands, and having damaged, poor quality residuals? Interestingly, this same argument ("it won't allow good forestry") is used to justify by-passing the FPA by both the state and large landowners (both groups of which helped create the FPA in the first place).
- *Having the cut be less than growth will lower the allowable cut to 17% below sustainble levels and lead to the forest getting old, with slower growth.* Apparently, this forester was using the Allowable Cut Effect to calculate "sustainable" harvest levels. I was impressed that this industry representative who, like Joseph McCarthy, waved his precisely-calculated study as he spoke, was able to come to such a level of precision when there were, as yet, no standards! Ironically, industry lands that were cut as heavily as the companies liked, ended up having some of the lowest volume per acre in the state. Much of their lands were covered with small-diameter trees and seedlings and saplings.
- *These standards will not only lead to less cutting, but also to fewer jobs.* From the perspective of time, this is one of the cruelist ironies. Large landowners have been able to do pretty much what they wanted to do (except rolling clearcuts, that went on for thousands of acres) and we still had a collapse in jobs because of mechanization, difficulty for logging contractors to find adequate quality wood, and mill closures. In the industrial forest region, we have had population declines, school closures, and store closures. Concern from industry representatives about workers and communities seems to come more from a desire to prevent regulations than to actually improve employment, wages or working conditions.